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Close-Range 3D Laser Scanning and Virtual Museums:

Beyond Wonder Chambers and Cabinets of Curiosity?

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Abstract

The popularity of three-dimensional laser scanning has significantly increased in recent years. This can likely be explained by the practicality of its applications as well as by the curiosity that drives its ever expanding audience of viewers, whether researcher or virtual museum patron. Common benefits of such data include virtual preservation and digital dissemination of objects and architecture in highly accurate, sub-millimeter resolution forms via the internet and virtual museum sites. While the practicality of these uses is self evident, one important question remains at the core of many discussions and debates concerning 3D laster scanning: what is the practical application of this data within the realm of research? Once removed from the curation and authority of a physical museum or laboratory, can a 3D object database or online virtual museum function beyond a mere cabinet of curiosities that comes with highly precise measurement tools? This paper aims to explore the analysis potential of laser scanning data and the role such analysis could play in formulating new research questions using the specific case of the Virtual Hampson Museum Project. This virtual museum is comprised of over 200 digitally scanned artifacts from the Hampson Archaeological Museum State Park in Wilson, Arkansas and includes a digital archive that has been made available online for 3D viewing using Adobe Reader or downloaded for viewing and analysis in a variety of common 3D formats. A review of available software tools and how these tools can be employed in analyses will be made. One of the most obvious benefits of such tools and datasets is the ability for increased precision in point to point measurements as well as volume, perimeter and surface area calculations. The usefulness of such information in ceramic analysis will be discussed along with other types of analytical methods that are unique to 3D point cloud data. These include hill shade analysis, curvature mapping, and texture/color stripping and their abilities to isolate surface features such as fine incising and other elements that are difficult to observe and evaluate effectively with traditional techniques.

Key words*: Laser Scanning*

1 Introduction

The adoption of 3D laser scanning by the field of archaeology has brought with it several commonly discussed benefits such as increased measurement precision, ability to reconstruct artifacts and reunite collections, and ease of investigation around an entire object with the possibility of sustained views at difficult angles. Most notably this technology facilitates virtual preservation and ease of digital data dissemination, two applications that were impossible prior to the advent 3D laser scanning. All of these possess value for people in various fields from museums and public education to field archaeology and archaeological technophilia. Undoubtedly there is some benefit to providing the ability for more people to see more objects and investigate them with more precise tools, however one critique persists among many: what is the application of all this within the realm of research? Can this technology allow for the development of new questions and spearhead new research directions? Or have digital 3D databases and virtual online museums merely invented virtual curiosity cabinets--just a new space for artifacts to exist and be viewed in? Furthermore, by extracting objects of antiquity from the context of museums and laboratories and the ever-present authority of curators and scientists are we not effectively stripping them of their scientific and cultural value? What effect will this have on casual visitors to a virtual museum website?

In response to such questions, this paper proposes that 3D laser scanning has the potential shed new light on old research questions as well as forge new directions in the field. With increased familiarity of toolboxes available in 3D point cloud software, researchers can find new means of investigating old questions as well as help formulate new ones. The following is a discussion of several available tools and their potential new research applications. Additionally, a short discussion of the role of 3d datasets, virtual museums and non-professional users will be made. Discussed examples are from the Virtual Hampson Museum Project and all virtual museum concepts are references to this type of next generation museum as discussed below.

The Virtual Hampson Museum Project is directed by the Center for Advanced Spatial Technology, University of Arkansas, and funded by the Arkansas Natural and Cultural Resources Council. It is a next generation virtual museum that provides high-resolution, 3-dimensional data of scanned artifacts from the Native American collections at the Hampson Archeological Museum State Park in Wilson, Arkansas. The Virtual Hampson Museum Project uses close range 3D laser scanning to document and digitally archive several hundred artifacts from the collections at the state park museum. Artifacts can be viewed in 3D on the website or downloaded in a variety of common 3D formats.

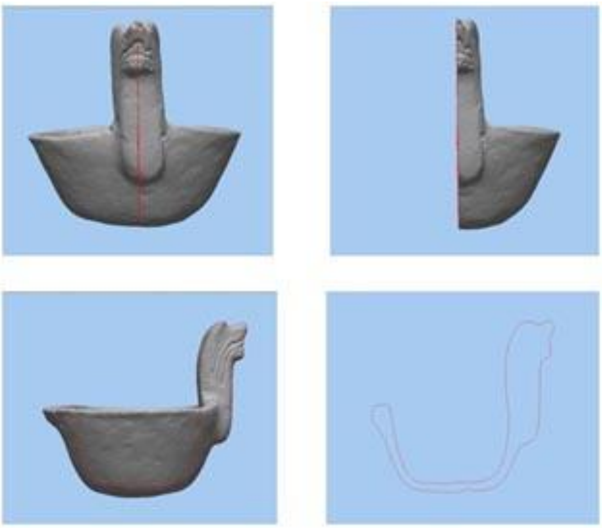

Figure 1. Cross sections

2 NEW TOOLS, NEW RESEARCH POTENTIAL

As previously mentioned, this technology provides a variety of exceedingly precise and complex measurement tools than previously available with traditional measurements tools. These tools the following:

1. Volume
2. Radius
3. Surface Area
4. Perimeter Length
5. Point to Point
    - can be constrained to an axis in 2D
    - can measure across the topography of a 3D surface
6. Vertices and Plane Angle including
    - including dihedral measurements

They have the ability to facilitate a number of innovative analysis that were not possible before. For example, **angle measurement** tools provide the means to precisely measure rim beveling angles in ceramic analysis, a measure that is difficult, if not impossible to determine using traditional physical tools. The ability of this measurement tool to further rim beveling research is increased significantly by the potential to automate such data extraction.

Cross sections can be generated from a variety of angles to produce profiles at any direction or axes. **Cross section** tools are ideal for measuring wall or feature thickness in a specific area or to analyze thickness variability around an entire object (Fig. 1). This provides a means of research in defining variation within an object, between objects, and between collections of a variety of vessels.

Color stripping options have the ability to reveal fine, small scale surface features on a variety of object types such as the incising on this shell artifact in the Hampson Collection (Fig. 2). It can also be used to reveal the details of carving and grain on wooden objects

Multiple 3D point cloud software tools can be used to reveal a number of surface treatments on ceramics including fine etching, punctations, dimpling, etc. One example is employment of **Curvature Mapping**

Figure 2. Color Stripping

Figure 3. Curvature Mapping

on this Greek vessel which is characterized by figures that were incised prior to painting and firing (Fig. 3)(Cole 2008). This tool can be employed to investigate manufacturing techniques and stylistic details that are otherwise obscured by paint or the object's material color. Additionally, software tools options allow the user to add lights and adjust the source direction and placement. This facilitates hill shade analysis and also aids in accentuation of surface features.

Another type of surface treatment analysis can be achieved through detection and isolation of relief features. For example, features such as relief ceramic motifs can be identified as either rims and/or valleys which can then be extracted from the vessel and viewed in isolation for ease of investigation and precision measurement (Fig. 4). If desired, such motifs can also be projected onto a plane or other primitive object.

Alternatively, motifs can be extracted through selection of like colors as illustrated in Fig. 5. Isolation of such motifs can allow for traditional rollouts (such as those generally used for publication) using additional software, however, more precise measurements can be achieved through 3D investigation. Additionally, 3D investigations of such motifs (as opposed to traditional rollouts) can allow retention of spatial integrity for comparative analysis amongst vessels of various types and sizes. Until now, researchers have not had the ability to accurately quantify and analyze variables such as spiral tightness, proportions, etc. in 3D space.

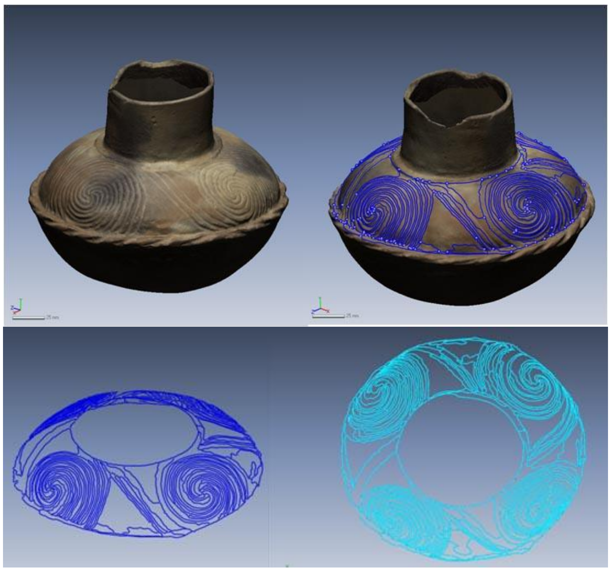

Figure 4. Feature Extraction

Figure 5. Feature Extraction

Ceramic research in the 1980s and 90s tested the assumption that standardization of pottery was evidence of craft specialization of a society. Through sample variation statistics, Kvamme et al (1996) demonstrated in the ethnographic case of two contemporary Philippine populations that the population that produced more standardized vessels indeed had more pottery specialists relative to the population without full-time potters. This conclusion was based on knowledge of emic ceramic classes that were indicated by members of the study population. Such class definitions and subsequent analysis were reliant on size variability. Degree of standardization was measured in three simple variables: height, width and aperture diameter. Unfortunately, in examining a prehistoric population, they are unable to make a reliable assessment of degree of ceramic standardization as knowledge of such ceramic classes was not available: “Without legitimate classes, group variation statistics lose meaning because they are totally dependent on how classes are defined" (Kvamme et al 1996). It is concluded that "Alternative, more effective means of measuring and assessing variability in ceramics can only help to untangle relationships between production intensity and product standardization" (Kvamme et al 1996).

I would propose that analysis of vessel symmetry may provide another measure of standardization that is not subject to the issues presented by reliance on size class categories. Such analysis would test the assumption that increased radial symmetry (i.e., regularity of roundness) in rim, neck, body and base represents increased product uniformity and thus reflects production intensity and presence of craft specialization. Such a measurement would involve the fitting of a primitive sphere in a vessel opening or body cross section. Use of the **Accuracy Analyzer** could then quantify the degree of variation from a perfectly round shape (Fig. 6). Alternatively, a number of diameter measurements could be taken of cross sections at each area of interest (rim, neck, body, base) and analyzed to create a measure of radial symmetry.

Another element not readily analyzed prior to 3D laser scanning is that of roughness or rugosity. Roughness (or smoothness) has traditionally been investigated as a relative measure within or between vessels using visual inspection. Such an observation has been used to analyze general use ware or more specifically significant phenomenon such as pot polish on ceramic vessels in the Southwest, United States--an indicator that bones were boiled in a vessel. One simple 3D tool that could measure surface roughness is **Surface Area**. This simple analysis could measure degree of roughness as greater surface area when compared to the same area that has been smoothed using a **Smoothing** tool or export a projected elevation model by creating an ellipsoid projection and import it into a geographic information system (GIS) for texture or roughness analysis. These approaches may be subject to error as smoothing or projecting may slightly alter overall curvature of a vessel area. A more effective and accurate approach would be to select an area of interest and export it into a GIS for use analysis using GIS **Bathymetry** tools.

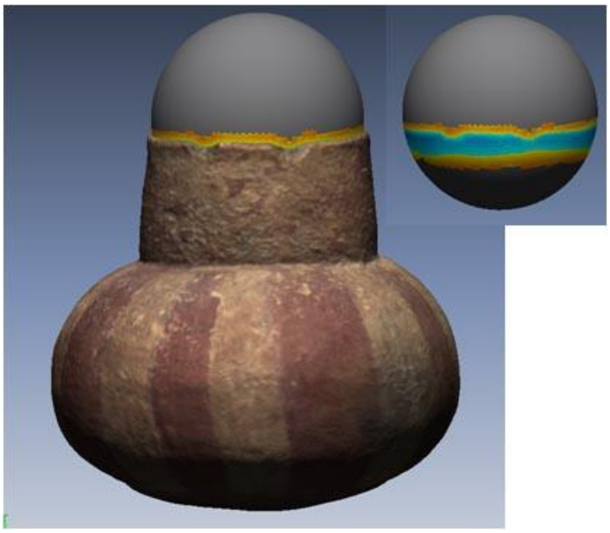

Figure 6. Accuracy Analyzer

In addition to the previously mentioned tools, there are two means of augmenting the their research applications within 3D point cloud analysis. The first is the potential to produce mean objects for a series of artifacts in order to facilitate analysis of variance within and between populations. Second, one could automate many of these processes, and radically increase sample populations from those that would otherwise be processed using manual methods.

2 3D ARCHAEOLOGY AND EDUCATION

Virtual museums and online digital object databases provide nearly limitless bounds for exploring and investigating objects, allowing one to juxtapose and categorize artifacts in any way one pleases. Like the curiosity cabinets of the Renaissance, virtual museums provide a space to experience a " typological exuberance achieved by juxtaposing different categories of material and placing the emphasis on agency and interaction, as opposed to confinement within a normalized, chronological order" (McClellan, A. 2003). This could certainly be an attractive venture for a young student of archaeology, however such freedom raises more questions among critics of the laser scanning on the hype surrounding virtual museums: by extracting objects of antiquity from the context of museums and laboratories and the ever-present authority of curators and scientists are we not effectively stripping them of their scientific and cultural value? Have we merely reinvented the primitive museum form--curiosity cabinets and *wundercammer* (wonder chambers) of the distant past prior to the birth of modern scientific thought? Before scientists and curators harnessed our unsupervised gazes into focused inspections of carefully categorized collections informed by meaningful placement in displays replete with interpretive texts?

While lack of boundaries or imposition of existing categories and chronologies on impressionable students may prompt fear of misguidance, such freedom for creativity in investigation may foster new analytical skills and the ability to be constructively critical. Online next generation virtual museums (i.e., virtual museums that provide downloadable 3D datasets/objects) provide students with a means to intimately investigate artifacts and collections in a way that facilitates an active, hands-on learning process. Such an involved hands-on process allows a student to engage in more advanced analysis which can, in turn, allow them greater potential to formulate their own archaeological questions. They could, perhaps, even find the ability to critique past or existing approaches to method and theory. For example, comparison and analysis of variation within and between ceramic typologies could graphically illustrate that such classifications were created for sherd types rather than vessel types and employment of such approaches may be misguided in investigation of whole collections.

3 CONCLUSIONS

In discussing the potential research applications of virtual archaeological collections for non-professional researchers i.e., students, we have, in a sense come full circle, from the curiosity cabinets to the traditional physical museum, to the technological present where widely disbursed collections can be reunited and endlessly compared and analyzed with ever expanding collections of collections that could never be possible in the physical world. However, in addition to intensified analysis and the resultant furthering of archaeological research for professionals, it also becomes a place where distribution and access to investigative tools will become democratized. Anyone with access to the internet has access to what was previously only available to experts and select students on the track to expertise. Access with as much or as little accompanying archaeological interpretation as they wish (that is, they may or may not look beyond the pictures and read the accompanying text). And in that sense we have returned to the curiosity cabinets of the renaissance, in which one did not need credentials to house a collection and the masses of Europe were exposed to the strange and wondrous curiosities of the world. And who can say such freedom would not have a significant impact on the direction of archaeological research. For it was during the renaissance, that a dramatic increase in dissemination of objects of curiosity accompanied the dawn of science. Admittedly such a comparison is stated in jest, but nevertheless, the current advancement in 3D laser scanning technology and software has opened up great new potential for analysis and a variety of means to achieve it, whether employed by professional or non-professional alike. Regardless of who makes advancement in new approaches using this technology, the future for research in archaeology and laser scanning is certainly promising and nothing less than beneficial for anyone who chooses to use it.

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